22. *The Experiment.*—In the experiments performed hitherto, I have made the abnormal part of the conductor by hanging upon the wires of the long secondary sheets of tinfoil 32 cm. deep, the length varying up to 10·5 m. Several observations of the electrometer throws are taken without the condenser, several with the condenser 1 m. long, several with the condenser 2 m. long, and so forth; check observations being taken while the condenser is being shortened again. Curve No. 2 is plotted with condenser lengths as abscissæ, and electrometer throws as ordinates; these latter, however, being reduced to the scale, electrometer throws without condenser equals unity. They thus compare with the values of I_t/I_0 in curve No. 1. The wave-length used was $\lambda_1 = 9$ m.

23. It is seen that the experimental curve thus obtained agrees in its general form with that plotted from theoretical considerations. Exact coincidence of theory and experiment cannot at this stage be expected. I have, accordingly, made no attempt to plot a curve from equation (18) with values of the constants which profess to exactly represent those involved in the experiment.

24. I am aware of two chief sources of disturbances in the experimental conditions, but have already shown that they are not of such order as to invalidate the above results, which, therefore, hold good as first approximations.

25. As the present paper is only a preliminary one, intended to give an outline of the theory and experiment, I will not now enlarge upon the topic of disturbances. I am still engaged on these interference phenomena, and hope to publish a full account of the results next session.

In conclusion, I wish to express my great indebtedness to Professor Hertz, both for first directing my attention to the subject of these reflections, and also for his invaluable advice in the course of the work.

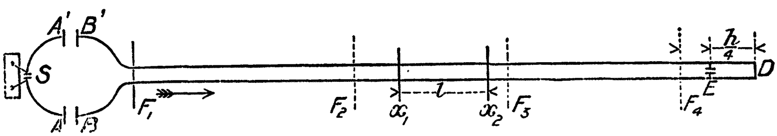
VI. "On Interference Phenomena in Electric Waves passing through different Thicknesses of Electrolyte." By G. UDNY YULE. Communicated by Professor G. CAREY FOSTER, F.R.S. Received May 31, 1893.

In the spring of 1889 Professor J. J. Thomson published* a description of some experiments made by him for comparing the resistances of electrolytes to the passage of very rapidly alternating currents, the method consisting in comparing the thicknesses of layers of different electrolytes which were equally opaque to Hertzian radiation. During

* 'Roy. Soc. Proc.,' vol. 45, p. 269, 1889.

last winter I made trial of an arrangement identical in principle but more completely analogous to Hughes' induction balance. The method seemed, however, to offer several difficulties and disadvantages, and finally I adopted another, also, one may say, analogous to Professor Thomson's, inasmuch as it measures transparencies, but in outward appearance completely different from his.

FIG. 1.



Let ASA′ be a Hertz exciter, and B, B′ secondary conductors similar to the primary from which a pair of long wires, stretched parallel to each other, are led off for a considerable distance. One may regard the wires simply as guides for the radiation, which then travels straight up the space between them. If we run these wires for a certain length, l, through an electrolyte, the radiation will have to traverse this and will be partly absorbed. If an electrometer be connected at E, a quarter wave-length from the bridge at the end of the wires, readings taken with various thicknesses of electrolyte should, according to my expectations, give a logarithmic curve, from which the specific resistance would be at once calculable.

The actual dimensions of the exciter, &c., erected were the same as those used by Bjerknes.*

A, A′, B, B′ circular zinc plates, diameter	40 cm.
Distance from A to B	30 „
Length of wire ASA′ (2 mm. diameter)	200 „
Wave-length, λ	900 „

The wires B, F, D, about 1 mm. diameter, were spanned 6 cm. apart. If these wires be made too short, a wave-train emitted from B, B′ may reach the electrolyte x_1, or the bridge D, be reflected, and return to B before the primary has practically done oscillating. If this occur, the state of the secondary may affect the primary as in an alternate current transformer. If, however, Bx_1 be made longer than half the effective length of the wave-train, the reflected waves will not reach B until the primary oscillations have practically come to rest, and under these circumstances the latter will know nothing about any alternations in the secondary at or beyond x_1. This reaction of the secondary on the primary had been first noticed, and to a serious

* 'Wiedemann's Annalen,' vol. 44, p. 513, 1891.

extent, by Herr J. Ritter von Geitler* with an exciter of the type used by Blondlot.†

In the actual apparatus the wires were at F_1 run out through a window in a loop of about 50 m. circumference round the laboratory garden. They re-entered the room at F_2 and were then run vertically through the vessel for containing the electrolyte. The circuit was completed by another loop, F_3F_4, 50 m. long, round the garden, re-entering the room at F_4, connecting to the electrometer at E, and bridged at D, 2·25 m. $= \frac{1}{4}\lambda$ from the electrometer. According to the researches of Bjerknes (*loc. cit.*) these dimensions should be sufficient, with the present apparatus, to prevent any sensible reaction.

The electrometer was the same one as that used by Bjerknes in his researches in the same laboratory. It is a simple quadrant electrometer with only one pair of quadrants and an uncharged aluminium needle of the usual shape suspended by a quartz fibre. One quadrant is connected to each wire. The needle taking no account of sign, elongations are simply proportional to the time integral of the energy: first throws, not steady deflections, are read.

Various glass jars were used for holding the electrolyte. The wires were run vertically through holes drilled in the bottom of the jar, into which they were cemented.

Several trials were made of this apparatus with dilute solutions of copper sulphate. Readings were taken in pairs alternately, with no solution in the jar and with some given thickness; usually about ten readings at each point. The ratio of the transmitted intensities so obtained was determined for several points and plotted as a curve. Some 5 or 6 cm. of electrolyte was the maximum thickness that could be used in these first experiments. The curves so obtained for these badly-conducting solutions always differed sensibly from the logarithmic, and the more so the more the solution was diluted. If the mean log. dec. over the whole thickness was taken, the corresponding value of the specific conductivity appeared extremely high.

It appeared likely that these irregularities might be due to interference effects analogous to Newton's rings (by transmission), or the phenomena of "thin plates," particularly in view of the results obtained just previously by Mr. E. H. Barton in the same laboratory. I consequently desired to investigate for such interference phenomena over as great a thickness of electrolyte as the absorption would permit of using. Distilled water offered itself naturally as the best electrolyte for this purpose.

For the containing vessel a glass cylinder 114 cm. high was used; the internal diameter varied somewhat, but was about 12 cm. at the narrowest.

* Doctor-Dissertation, Bonn, Jan., 1893, p. 22.

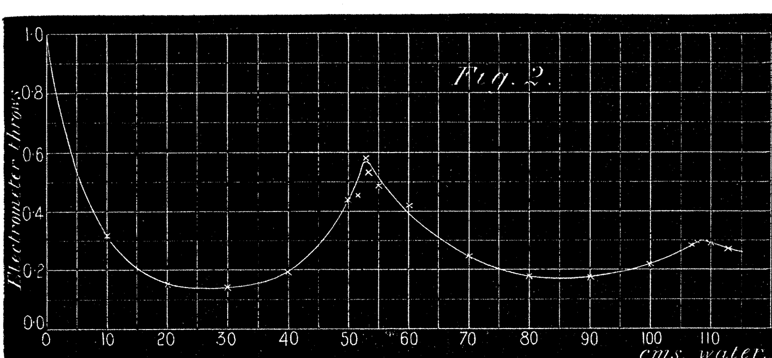
† 'Compt. Rend.,' vol. 114, p. 283, Feb., 1892.

With this apparatus a series of observations were made for various thicknesses of distilled water. To cover, as far as possible, irregularities in sparking, readings were now taken in pairs alternately at the point to be determined and some other point taken for the time as the standard; it would have caused too great delay, and consequent irregularity in the effectiveness of the sparks, were all the water to be siphoned out between each pair of readings. As before, ten or twelve readings were usually taken at each point. The throw obtained with no liquid was also always taken as unity.

As a specimen of the usual spark variations, the following series of readings for the determination of the throw with 55 cm. water with reference to 40 cm. will serve. The series is taken quite at random from the others.

40 cm.		55 cm.
4·6	....	11·4
4·9	....	11·4
5·0	....	11·0
4·2	....	11·9
4·3	....	11·5
3·9	....	11·2
4·0	....	11·6
4·3	....	11·4
4·6	....	10·4
4·4	....	11·2
4·5	....	10·4
4·6	....	10·0

The readings are grouped separately, but it will be understood that they were taken in pairs alternately.



The complete results are given in the curve (Fig. 2). It is seen that for such a poor conductor as distilled water the interference

completely masks the absorption effects. The intensity of the transmitted ray does *not* steadily decrease; on the contrary, far more may be transmitted through a thick than through a thin layer of the absorbent medium. The transmission follows the same general law as for light with a thin plate; we are, in fact, dealing with a "thin" plate—a plate whose thickness is comparable with the wave-length. The intensity of the transmitted ray is a minimum for a plate $\frac{1}{4}\lambda$ thick, a maximum for $\frac{1}{2}\lambda$ thick, a minimum again for $\frac{3}{4}\lambda$, and so on.

The points on the curve round the maximum at $\frac{1}{2}\lambda$ are somewhat irregular, and the two maxima do not absolutely agree. Taking the mean, we may say the wave-lengths in air and water are respectively:—

$$\lambda_a = 900. \qquad \lambda_w = 108 \text{ cm.}$$

This gives us for the coefficient of refraction and the dielectric constant—

$$n = 8\cdot33. \qquad \kappa = 69\cdot5.$$

The following are the values of κ found by previous investigators, all that are known to me:—

Method used.	Authority.	κ.
Alternated currents ..	Heerwagen*	79·56
	Rosa†	75·70
	Rosa‡	70·60
Ruhmkorff coil......	Cohn and Arons§	76·00
	Tereschin‖	83·80
Hertz oscillations	Cohn¶	73·50
	Ellinger**	81·00
	Itschegtiaeff††	1·75

Excluding the Russian physicist as a negligible minority, it will be seen that my value of κ is somewhat low. The cause may lie in

* 'Wied. Ann.,' vol. 48, p. 35, 1893.

† 'Phil. Mag.,' vol. 31, p. 200, 1891.

‡ *Ibid.*, vol. 34, p. 344, 1892.

§ 'Wied. Ann.,' vol. 33, p. 13, 1888.

‖ *Ibid.*, vol. 36, p. 792, 1889.

¶ *Ibid.*, vol. 45, p. 370, 1892.

** *Ibid.*, vol. 46, p. 513, 1892.

†† 'Phil. Mag.,' vol. 34, p. 388, 1892.

the fact that not the whole of the field surrounding the wires lies in the water.

The uncertainty due to this stray field might be easily avoided in one way, namely, by making one wire into a tube surrounding the other and using this tube also as the jar for the electrolyte. This was, in fact, the arrangement originally intended to be adopted. Several disadvantages attended it, however, and led to its final rejection in favour of the simple wires and glass jar. First, such a condenser reflects under all circumstances a considerable portion of the incident energy.* Secondly, the variation of the position of the top surface of the electrolyte relatively to the top of the jar would introduce fresh interference phenomena. This appeared directly from the work of Mr. Barton to which I have already had occasion to refer. Lastly, the large surface of metal in contact with the liquid would render distilled water rapidly impure.

This investigation was carried out in the Physical Institute of the University of Bonn. I desire particularly to express my thanks to Professor Hertz for his most useful advice and suggestions.

VII. "On the Ratio of the Specific Heats of the Paraffins and their Monohalogen Derivatives."

By J. W. CAPSTICK, M.Sc. (Vict.), B.A. (Camb.), Scholar and Coutts-Trotter Student of Trinity College, Cambridge. Communicated by Professor J. J. THOMSON, F.R.S. Received May 25, 1893.

(Abstract.)

The experiments were undertaken to find whether the internal energy of the molecules of organic gases, as deduced from the ratio of the specific heats, showed any regularities corresponding to the chemical resemblances symbolised by the graphic formulæ.

The paraffins and their monohalogen derivatives are very suitable for the purpose, as their chemical relations to each other are simple, they are easily volatile, and are stable enough to be unaffected by ordinary purifying agents.

From the ratio of the specific heats we can calculate the relative rates of increase of the internal energy and the energy of translation of the molecules per degree rise of temperature, and, the aim of the experiments being to compare the rates of increase of the internal energy of different gases, it was decided to keep the translational energy constant by working at a constant temperature. Consequently the determinations were all made at the temperature of the room.

The ratio of the specific heats was calculated from the velocity of

* J. Ritter von Geitler, Doctor-Dissertation, Bonn, Jan., 1893.

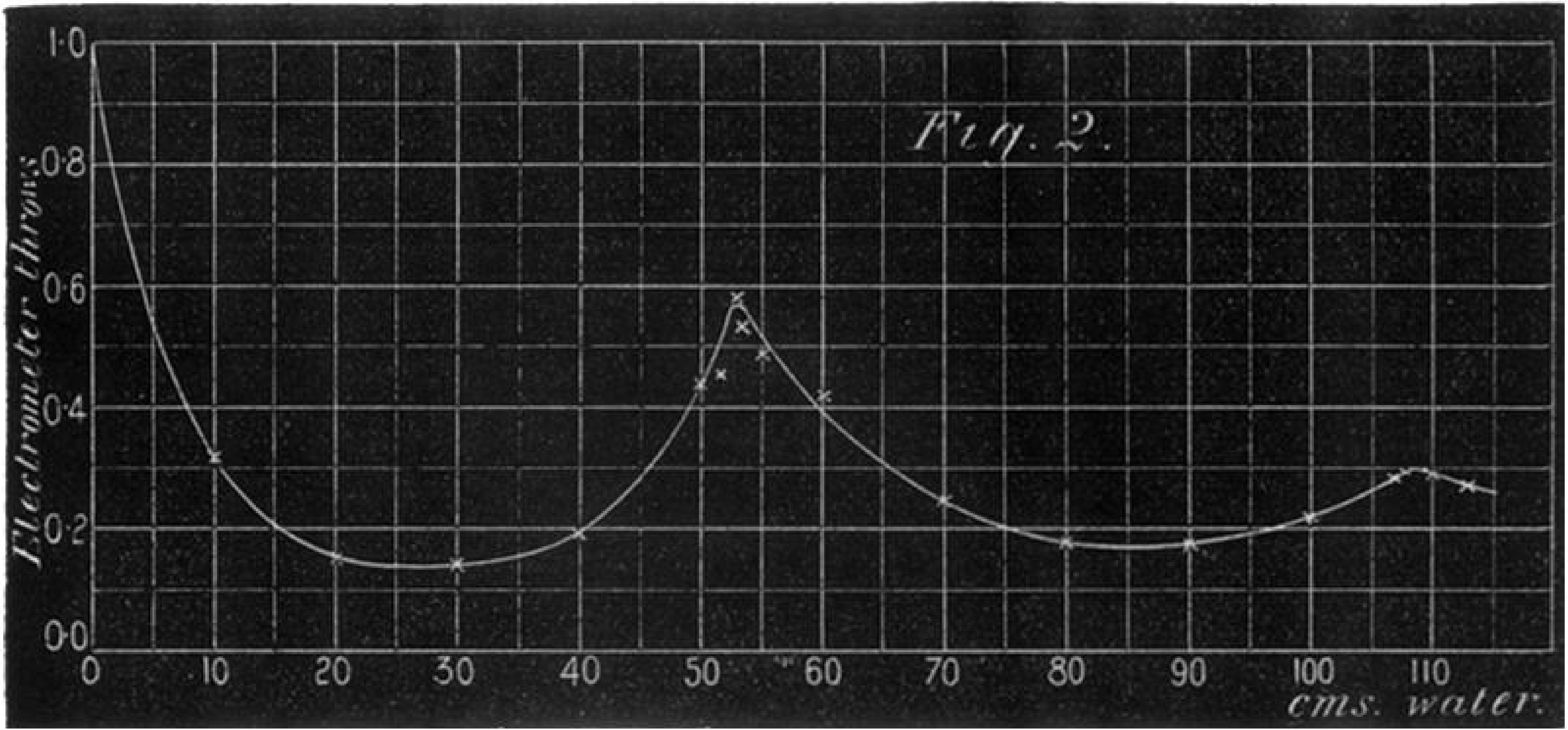


Fig. 2.
Electrometer throws
1·0
0·8
0·6
0·4
0·2
0·0
0
10
20
30
40
50
60
70
80
90
100
110
cms. water.